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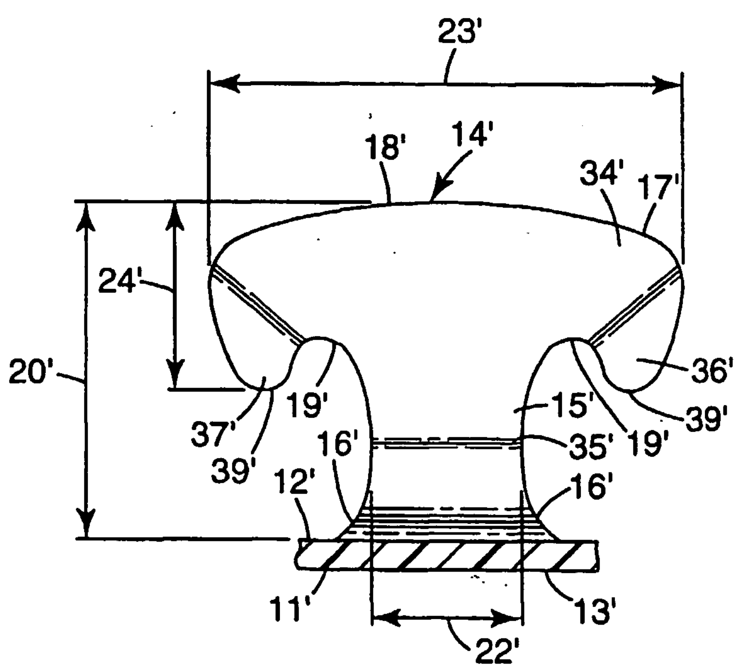
(54) Title: HEAT TREATED PROFILE EXTRUDED HOOK



(57) Abstract: A method for forming a unitary polymeric projection or fastener comprising a thin, strong flexible backing, and a multiplicity of thin spaced hook members projecting from the upper surface of the unitary backing the method generally including extruding a thermoplastic resin through a die plate which die plate is shaped to form a base layer and spaced ridges, ribs or hook elements projecting above a surface of the base layer. When the die forms the spaced ridges or ribs the cross sectional shape of the hook members are formed by the die plate while the initial hook member thickness is formed by transversely cutting the ridges at spaced locations along their lengths to form discrete cut portions of the ridges. Subsequently longitudinal stretching of the backing layer (in the direction of the ridges on the machine direction) separates these cut portions of the ridges, which cut portion then form spaced apart hook members. The extruded hook members or cut rib hook members are then heat treated resulting in shrinkage of at least a portion of at least the hook head portion thickness by from 5 to 90 percent, preferably 30 to 90 percent.

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HEAT TREATED PROFILE EXTRUDED HOOK

Background and Summary

The present invention concerns molded hook fasteners for use with hook and loop fasteners.

Background of the Invention

There are a variety of methods known to form hook materials for hook and loop fasteners. One of the first manufacturing methods for forming hooks involved weaving loops of monofilaments into a fibrous or film backing or the like followed by cutting the filament loops to form hooks. These monofilament loops were also heated to form headed structures such as disclosed in U.S. Patent Nos. 4,290,174; 3,138,841 or 4,454,183. These woven hooks are generally durable and work well for repeated uses. However, they are generally expensive and coarse to the touch.

For use in disposable garments and the like, it was generally desirable to provide hooks that were inexpensive and less abrasive. For these uses and the like, the solution was generally the use of continuous extrusion methods that simultaneously formed the backing and the hook elements, or precursors to the hook elements. With direct extrusion molding formation of the hook elements, see for example U.S. Patent No. 5,315,740, the hook elements must continuously taper from the backing to the hook tip to allow the hook elements to be pulled from the molding surface. This generally inherently limits the individual hooks to those capable of engaging only in a single direction while also limiting the strength of the engaging head portion of the hook element.

An alternative direct molding process is proposed, for example, in U.S. Patent No. 4,894,060, which permits the formation of hook elements without these limitations. Instead of the hook elements being formed as a negative of a cavity on a molding surface, the basic hook cross-section is formed by a profiled extrusion die. The die simultaneously extrudes the film backing and rib structures. The individual hook elements are then formed from the ribs by cutting the ribs transversely followed by stretching the extruded strip in the direction of the ribs. The backing elongates but the cut rib sections remain substantially unchanged. This causes the individual cut sections of the ribs to separate each from the other in the direction of elongation forming discrete hook elements.

Alternatively, using this same type extrusion process, sections of the rib structures can be milled out to form discrete hook elements. With this profile extrusion, the basic hook cross section or profile is only limited by the die shape and hooks can be formed that extend in two directions and have hook head portions that need not taper to allow extraction from a molding surface. This is extremely advantageous in providing higher performing and more functionably versatile hook structures. However, a limitation with this method of manufacture is in forming hook structures that are extremely narrow in the extrusion direction of the ribs or the cut direction. Cutting the formed ribs at very closely spaced intervals is difficult at commercially acceptable production speeds. Further, when the cut length is extremely closely spaced the previously cut portions of the ribs tend to fuse due to the heat created by the cutting operation. As such, there is a need to improve this process so as to allow for production of narrower hook profiles and formation of the narrower hook profiles at commercially acceptable production speeds.

Brief Description of the Invention

The present invention provides a method for forming preferably a unitary polymeric hook fastener comprising a thin, strong flexible backing, and a multiplicity of thin, spaced hook members projecting from the upper surface of the unitary backing. The method of the invention generally can be used to form thin upstanding projections, which may or may not be hook members that project upwardly from the surface of a unitary film backing of at least a uniaxially oriented polymer. The hook members each comprise a stem portion attached at one end to the backing, and a head portion at the end of the stem portion opposite the backing. The head portion can also extend from a side of a stem portion or be omitted entirely to form alternative projections which can be other forms than a hook member. For hook members, the head portion preferably projects past the stem portion on at least one of two opposite sides. At least the hook head portions have been heat treated so as to decrease the hook head thickness and thereby reducing or eliminating molecular orientation in at least the hook head in the machine direction. Generally, the hook members suitable for use in the invention method, both before and after treatment, have a height dimension from the upper surface of the backing of less than 5000 μm. The stem and head portions generally have a thickness dimension of less than 1500 μm in a first direction parallel to the surfaces of the backing. The stem portions each

have a width dimension in the range of 50 to 500 μm in a second direction, generally at a right angle to the first direction and parallel to the surfaces of the backing, and the head portions each have a width dimension in the second direction that is between 50 and 2000 μm greater than the width dimension of the stem portion and a total width of less than 5000 μm. There are generally at least 10, preferably 20 to 200 or 20 to 300 hook members per square centimeter of the base.

The fastener is preferably made by a novel adaptation of a known method of making hook fasteners as described, for example, in U.S. Patent Nos. 3,266,113; 3,557,413; 4,001,366; 4,056,593; 4,189,809 and 4,894,060 or alternatively 6,209,177. The preferred method generally includes extruding a thermoplastic resin through a die plate which die plate is shaped to form a base layer and spaced ridges, ribs or hook elements projecting above a surface of the base layer. These ridges generally form the cross-section shapes of the desired projection to be produced, which is preferably a hook member. When the die forms the spaced ridges or ribs the cross sectional shape of the hook members are formed by the die plate while the initial hook member thickness is formed by transversely cutting the ridges at spaced locations along their lengths to form discrete cut portions of the ridges. Subsequently longitudinal stretching of the backing layer (in the direction of the ridges on the machine direction) separates these cut portions of the ridges, which cut portion then form spaced apart hook members. The extruded hook members or cut rib hook members are then heat treated resulting in shrinkage of at least a portion of at least the hook head portion thickness by from 5 to 90 percent, preferably 30 to 90 percent. In an alternative embodiment, the heat treatment is continued to likewise shrink at least a portion of the stem portion of the hook members. The resulting heat treated projections, preferably hooks, are substantially upstanding or rigid such that they do not droop toward the base layer or are able to penetrate a fibrous or like substrate.

Brief Description of the Drawings

The present invention will be further described with reference to the accompanying drawings wherein like reference numerals refer to like parts in the several views, and wherein:

FIGURE 1 schematically illustrates a method for making the hook fastener portion of Fig. 4.

FIGURES 2 and 3 illustrate the structure of a strip at various stages of its processing in the method illustrated in Fig. 1.

FIGURE 4 is an enlarged perspective view of a hook fastener.

FIGURES 5a and 5b are enlarged fragmentary side and end views, respectively, of one hook member in the hook fastener portion of Fig. 4.

FIGURES 6a and 6b are views of Figs. 5a and 5b, respectively, after limited heat treating of the hook member.

FIGURES 7a and 7b are views of Figs. 5a and 5b, respectively, after heat treating of the entire hook member.

FIGURES 8 and 9 are enlarged fragmentary sectional views of alternate embodiments of hook portions that can be used in hook fastener portions according to the present invention;

FIGURE 10 is an alternative embodiment of individual extruded hook elements that can be heat treated in accordance with the invention method.

FIGURE 11 is a cross-sectional view of a fully heat treated alternative hook member in accordance with the invention.

FIGURE 12 is a cross-sectional view of a heat treated hook member in accordance with the invention.

FIGURE 13 is a cross-sectional view of a fully heat treated hook member in accordance with the invention.

FIGURE 14 is a cross-sectional view of a fully heat treated hook member in accordance with the invention.

Detailed Description of the Preferred Embodiment

Referring now to Fig. 4 is an exemplary polymeric hook fastener portion, which can be produced, or heat treated according to the present invention is generally designated by the reference numeral 10. The hook fastener portion 10 comprises a thin strong flexible film-like backing 11 having generally parallel upper and lower major surfaces 12 and 13, and a multiplicity of spaced hook members 14 projecting from at least the upper surface 12 of the backing 11. The backing can have planar surfaces or surface features as could be desired for tear resistance or reinforcement. As is best seen in Fig. 5, the hook members 14 each comprise a stem portion 15 attached at one end to the backing 11 and preferably

having tapered sections 16 that widen toward the backing 11 to increase the hook anchorage and breaking strengths at their junctures with the backing 11, and a head portion 17 at the end of the stem portion 15 opposite the backing 11. The sides 34 of the head portion 17 can be flush with the sides 35 of the stem portion 15 on two opposite sides. The head portion 17 has hook engaging parts or arms 36, 37 projecting past the stem portion 15 on one or both sides 38. The hook member shown in Figs. 5a and 5b has a rounded surface 18 opposite the stem portion 15 to help the head portion 17 enter between loops in a loop fastener portion. The head portion 17 also has transverse cylindrically concave surface portions 19 at the junctures between the stem portion 15 and the surfaces of the head portion 17 projecting over the backing 11.

With reference to Figs. 5a and 5b, there is shown a single representative one of the small hook members 14 on which its dimensions are represented by reference numerals between dimensional arrows. The height dimension is 20. The stem and head portions 15 and 17 have a thickness dimension 21, which as shown is the same, and the head portions 17 have a width dimension 23 and an arm droop 24. The stem portion has a width dimension 22 at its base before flaring 16 to the base film 11. The thickness as shown is for a rectilinear shaped hook, with other shapes the thickness can be measured as the shortest distance between two opposing sides 34 or 35. Likewise, the width dimension can be measured as the shortest distance between two opposing sides.

Figs. 8 and 9 illustrate two of many alternate shapes that could be used for the hook members in alternate embodiments of the hook members that can be heat treated in accordance with the invention method.

The hook member 25 illustrated in Fig. 8 differs from the hook member 14 of Fig. 5 in that its head portion 26 projects farther on opposite sides from its stem portion 27 and is generally uniformly thick so that it can more easily bend to engage with or disengage from loops on a loop fastener portion.

The hook member 30 illustrated in Fig. 9 differs from the hook member 14 of Fig. 5 in that its head portion 31 projects from only one side of its stem portion 32 and will thus cause significantly greater peel forces when peeled away from the direction the head portion 31 projects than when it is peeled toward the direction the head portion 31 projects.

A first embodiment method for forming a hook fastener portion, such as that of Fig 4, is schematically illustrated in Fig. 1. Generally, the method includes first extruding a strip 50 shown in Fig. 2 of thermoplastic resin from an extruder 51 through a die 52 having an opening cut, for example, by electron discharge machining, shaped to form the strip 50 with a base 53 and elongate spaced ribs 54 projecting above an upper surface of the base layer 53 that have the cross sectional shape of the hook portions or members to be formed. The strip 50 is pulled around rollers 55 through a quench tank 56 filled with a cooling liquid (e.g., water), after which the ribs 54 (but not the base layer 53) are transversely slit or cut at spaced locations along their lengths by a cutter 58 to form discrete portions 57 of the ribs 54 having lengths corresponding to about the desired thicknesses of the hook portions to be formed, as is shown in Fig. 3. The cut can be at any desired angle, generally from 90° to 30° from the lengthwise extension of the ribs. Optionally, the strip can be stretched prior to cutting to provide further molecular orientation to the polymers forming the ribs and/or reduce the size of the ribs and the resulting hook members formed by slitting of the ribs. The cutter 58 can cut using any conventional means such as reciprocating or rotating blades, lasers, or water jets, however preferably it cuts using blades oriented at an angle of about 60 to 80 degrees with respect to lengthwise extension of the ribs 54.

After cutting of the ribs 54, the base 53 of the strip 50 is longitudinally stretched at a stretch ratio of at least 2 to 1, and preferably at a stretch ratio of about 4 to 1, preferably between a first pair of nip rollers 60 and 61 and a second pair of nip rollers 62 and 63 driven at different surface speeds. Optionally, the strip 50 can also be transversely stretched to provide biaxial orientation to the base 53. Roller 61 is preferably heated to heat the base 53 prior to stretching, and the roller 62 is preferably chilled to stabilize the stretched base 53. Stretching causes spaces between the cut portions 57 of the ribs 54, which then become the hook portions or members 14 for the completed hook fastener portion 10. The formed hook members are then heat treated preferably by a non-contact heat source 64. The temperature and duration of the heating should be selected to cause shrinkage or thickness reduction of at least the head portion by from 5 to 90 percent. The heating is preferably accomplished using a non-contact heating source which can include radiant, hot air, flame, UV, microwave, ultrasonics or focused IR heat lamps. This heat treating can be over the entire strip containing the formed hook portions or can be over

only a portion or zone of the strip. Or different portions of the strip can be heat treated to more or less degrees of treatment. In this manner, it is possible to obtain on a single strip hook containing areas with different levels of performance without the need to extrude different shaped rib profiles. This heat treatment can change hook elements continuously or in gradients across a region of the hook strip. In this manner, the hook elements can differ continuously across a defined area of the hook member. Further, the hook density can be the same in the different regions coupled with substantially the same film backing caliper or thickness (e.g., 50 to 500 microns). The caliper can easily be made the same as the hook strip will have the same basis weight and same relative amount of material forming the hook elements and backing in all regions despite the difference in the shape of the hooks caused by the subsequent heat treating. The differential heat treatment can be along different rows or can cut across different rows, so that different types of hooks, such as hooks having different hook thicknesses, can be obtained in a single or multiple rows in the machine direction or the lengthwise direction of the hook strip. The heat treatment can be performed at any time following creation of the hook element, such that customized performance can be created without the need for modifying the basic hook element manufacturing process.

Fig. 6 shows a hook member of the Fig. 5 hook after it has been heat treated to cause a reduction in the thickness 21' of the hook head portion 17'. The other dimensions of the hook member can also change which is generally as a result of conservation of mass. The height 20' generally increases a slight amount and the head portion width 23' increases as does the arm droop 24'. The stem and head portions now have a thickness dimension 21' that is nonuniform and tapers from the base to the head portion due to the incomplete heat treatment along the entire hook member 14'. Generally the untreated portion has a uniform thickness corresponding to the original thickness 21, the generally fully heat treated portion will have a uniform thickness 21' with a transition zone separating the untreated and treated portions. In this embodiment, the incomplete heat treatment also results in variation of the thickness 21' of the hook head portion from the arm tip to the arm portion adjacent the stem 15'. All other numbered elements in Figs. 6a and 6b correspond to the numbered elements of Figs. 5a and 5b.

Reduction in the hook member thickness is caused by relaxation of at least the melt flow induced molecular orientation of the hook head and/or stem portion which is in the

machine direction, which generally corresponds to the thickness direction. Also, further reduction in thickness can occur where there is stretch induced molecular orientation, as where the ribs are stretched longitudinally prior to cutting. Melt induced molecular orientation is created by the melt extrusion process as polymer, under pressure and shear forces, is forced through the die orifice(s). The rib or ridge forming sections of the die create the molecular orientation in the formed ribs. This molecular orientation extends longitudinally or in the machine direction along the ribs or ridges. When the ribs or ridges are cut, the molecular orientation extends generally in the thickness dimension of the cut ribs, or cut hook members, however, the molecular orientation can extend at an angle of from about 0 to 45 degrees to the hook member thickness. The initial molecular orientation in the hook members is generally at least 10 percent, preferably 20 to 100 percent (as defined below). When the hook members are heat treated in accordance with the invention, the molecular orientation of the hook members decrease and the hook member thickness dimension decreases. The amount of thickness reduction depends primarily on the amount of hook member molecular orientation extending in the machine direction or hook thickness dimension. The heat treatment conditions, such as time of treatment, temperature, the nature of the heat source and the like can also effect the hook member thickness reduction. As the heat treatment progresses, the reduction in hook member, or projection thickness extends from the hook head portion, or top of the projection, to the stem portion, or down the projection to the base, until the entire hook member thickness has been reduced. Generally, the thickness reduction is substantially the same in the stem and the hook head portions when both are fully heat treated or partially heat treated to the same extent. When only a part of the hook head portion and/or hook head portion and stem portion are heat treated, there is a transition zone where the thickness increases from the upper heat treated portion, generally the head portion, to the substantially non-heat treated portion of the stem portion, or stem portion and part of the hook head portion, which have a substantially unreduced thickness. When the thickness dimension shrinks, the width of the treated portion generally increases, while the overall hook member height increases slightly and the arm droop increases. The end result is a hook thickness that can either, not be economically produced directly, or cannot be produced at all by conventional methods. The heat treated projection, generally the hook head, and optionally stem, is also characterized by a molecular orientation level of less

than 10 percent, preferably less than 5 percent where the base film layer orientation is substantially unreduced. Generally, the hook member stem or projection orientation immediately adjacent the base film layer will be 10 percent or higher, preferably 20 percent or higher.

Fig. 7 is a schematic view of a hook member of the Fig. 5 hook, where the entire hook member has been subjected to heat treatment. In this case, both the hook head portion 17" and the stem portion 15" have shrunk in the thickness direction with corresponding increases in the width dimensions 23" and 22" and arm droop 24". In this case, both the stem and head portion have a generally uniform thickness dimension 21", which is less than the initial hook member width dimension 21. The tapered section 16" is generally larger than the initial tapered section 16 due the thickness reduction in the stem portion.

The heat treatment is generally carried out at a temperature near or above the polymer melt temperature. As the heat gets significantly above the polymer melt temperature, the treatment time decreases so as to minimize any actual melting of the polymer in the hook head portion or top of the projection. The heat treatment is carried out at a time sufficient to result in reduction of the thickness of the hook head, and/or stem, but not such that there is a significant deformation of the backing or melt flow of the hook head portion or top of the projection. Heat treatment can also result in rounding of the hook head portion edges, improving tactile feel for use in garment applications.

Unexpectedly it has been discovered, that for high performance microhook engagement with certain low cost or low loft loop fabrics, that this heat treatment substantially increases engagement of the microhooks to the loop fabrics. A particularly preferred novel, microhook member producible by the invention method has been discovered where the hook members have a height of less than 1000 μm, preferably from 300 to 800 μm, and at least a head portion with a thickness of from 50 to 200 μm, preferably 50 to 180 μm. The other dimensions for this improved microhook include a stem width, as defined above, of from 50 to 500 μm, a head portion width of from 100 to 800 μm, and an arm droop of from 50 to 700 μm, preferably 100 to 500 μm, and a hook density of at least 50 and preferably from about 70 to 150, up to 300, hooks per square centimeter. This novel microhook hook portion exhibits improved overall performance to a variety of low loft loop fabrics.

Suitable polymeric materials from which the hook fastener portion can be made include thermoplastic resins comprising polyolefins, e.g. polypropylene and polyethylene, polyvinyl chloride, polystyrene, nylons, polyester such as polyethylene terephthalate and the like and copolymers and blends thereof. Preferably the resin is a polypropylene, polyethylene, polypropylene-polyethylene copolymer or blends thereof.

The backing of the fastener must be thick enough to allow it to be attached to a substrate by a desired means such as sonic welding, heat bonding, sewing or adhesives, including pressure sensitive or hot melt adhesives, and to firmly anchor the stems and provide resistance to tearing when the fastener is peeled open. However, when a fastener is used on a disposable garment, the backing should not be so thick that it is stiffer than necessary. Generally, the backing has a Gurley stiffness of 10 to 2000, preferably 10 to 200 so as to allow it to be perceived as soft when used either by itself or laminated to a further carrier backing structure such as a nonwoven, woven or film-type backing, which carrier backing should also be similarly soft for use in disposable absorbent articles. The optimum backing thickness will vary depending upon the resin from which the hook fastener portion is made, but will generally be between 20 μm and 1000 μm, and is preferably 20 to 200 μm for softer backings.

An alternative method for extruding hook members from a die is described in U.S. Patent No. 6,209,177 which results in hook fastening portions such as shown in Fig. 10. Each of the hook members comprises a stem portion 41 projecting from the surface of the backing 42 and a hook head 43 projecting from an end of the stem portion 41 sideways in at least one direction. A thickness of the hook member 40, which is perpendicular to a projecting direction of the hook head portion 43 of the hook member 40, gradually increases from a top portion of the hook head portion 43 toward a rising base end of the stem portion 41. With these hook members 40 each hook member 40 is molded independently of each other and integral with the surface of the backing substrate 42, in contrast to cutting of ribs and drawing of the backing substrate. The molten resin is extruded through a die plate however in this method a face of the die includes an ascending/descending member vertically reciprocating in sliding contact with a front of the die face interrupting polymer flow to the die elements forming the ridges. During extrusion molding the molten resin constantly forms the base while the ascending and descending movement of an ascending/descending member interrupts flow to the rib

section resulting in a vertical line of a plurality of separate hook members 40 continuously extending from the backing substrate 42.

The invention microhooks have been formed to be particularly useful in engaging with low profile nonwoven laminates. Most notably improved engagement has been unexpectedly discovered where the hooks have relatively low arm droop, and the ratio of the arm droop to the thickness of the nonwoven portion of a nonwoven laminate is less than 1.5, preferably less than 1.3 and most dramatically when less than 1.0. The peel force (135 degree) is generally above 120 grams/2.5 cm, preferably greater than 200 grams/2.5 cm.

Suitable low profile nonwoven laminates are laminates of a nonwoven fabric or web to a film or a higher strength nonwoven fabric or web. A "nonwoven fabric or web" is a web of individual fibers or threads which are randomly associated fibers that are not associated in a regular manner such as in a knitted fabric. Nonwoven fabrics or webs can be formed from processes such as, for example, meltblowing, spunbonding, spunlace and bonded carded webs.

In a preferred embodiment, the laminate is a film/nonwoven laminate where the nonwoven fabric, preferably a spunbond web, is thermally or extrusion bonded to a film. The film can have a center bonding layer which is made from a polymer which more easily bonds to the nonwoven, such as a semi-crystalline/amorphous with a base layer of another polymer, such as a polyolefin. Pigments can also be used in the base layer.

Suitable bonding layers include polymers such as disclosed in European Patent Application EP 0444671 A3, European Patent application EP 0472946 A2, European Patent Application EP 0400333 A2, U.S. Patent No. 5,302,454 and U.S. Patent No. 5,368,927 and other bonding polymers include ethylene-n-butyl acetate, ethylene/vinyl acetate copolymers, ethylene/methyl acetate copolymers, ethyl acrylic acid and other copolymers, and terpolymers of polypropylene, polyethylene and polybutylene as well as elastomers such as styrene conjugated diene block copolymer such as SEBS, SEPS, SBS, and urethanes.

A base layer used with bonding layer may be a polypropylene polymer or copolymer. Since this layer is relatively thick, the majority of opacity if desired may be added to this layer through the use of opacifiers such as, for example, TiO_2 or $CaCO_3$. The nonwoven and the film or higher strength nonwoven component are preferably

bonded together using thermal point bonding (heat or ultrasonic bonding). The point bonding if used should be at a density that would allow hooks to penetrate into the nonwoven, generally 30 percent or less, and preferably 20 percent or less. The lower bond area limit depends on the integrity of the laminate and the bond strength at the points but it is generally greater than 1 to 2 percent. A compatible tackifying resin may also be added to the bonding layer.

The nonwoven used in the laminates preferably is produced by meltblowing or spunbonding processes, which processes are well known in the art. The extruded fibers were generally deposited on a moving foraminous mat or belt to form the nonwoven fabric. The fibers produced in the spunbond and meltblown processes have average fiber diameters of less than 75 microns and less. Meltblown fibers are able to be produced having average fiber diameter of 10 microns and less, to about 1 micron. Spunbond fibers are generally 25 microns or more and are preferred for use to engage with the invention microhooks due to their greater strength. The nonwoven portion of the laminate generally has a thickness of from 100 to 300 microns, preferably from 100 to 200 microns and has a basis weight of from 10 to 50 g/m^2.

Test Methods

135 Degree Peel Test

The 135 degree peel test was used to measure the amount of force that was required to peel a sample of the mechanical fastener hook material from a sample of loop fastener material. A 5.1 cm x 12.7 cm piece of a loop test material was securely placed on a 5.1 cm x 12.7 cm steel panel by using a double-coated adhesive tape. The loop material was placed onto the panel with the cross direction of the loop material parallel to the long dimension of the panel. A 1.9 cm x 2.5 cm strip of the mechanical fastener to be tested was cut with the long dimension being in the machine direction of the web. A 2.5 cm wide paper leader was attached to the smooth side of one end of the hook strip. The hook strip was then centrally placed on the loop so that there was a 1.9 cm x 2.5 cm contact area between the strip and the loop material and the leading edge of the strip was along the length of the panel. The strip and loop material laminate was then rolled by hand, twice in each direction, using a 1000 gram roller at a rate of approximately 30.5 cm per minute. The sample was then placed in a 135 degree peel jig. The jig was placed into the bottom

jaw of an Instron™ Model 1122 tensile tester. The loose end of the paper leader was placed in the upper jaw of the tensile tester. A crosshead speed of 30.5 cm per minute and a chart recorder set at a chart speed of 50.8 cm per minute was used to record the peel force as the hook strip was peeled from the loop material at a constant angle of 135 degrees. An average of the four highest peaks was recorded in grams. The force required to remove the mechanical fastener strip from the loop material was reported in grams/2.54 cm-width. A minimum of 10 tests were run and averaged for each hook and loop combination.

Two different loop materials were used to measure the performance of the mechanical fastener hook material. Loop material 'A' is a nonwoven loop made similar to that described in U.S. Patent No. 5,616,394 Example 1, available from the 3M Company as KN-1971. Loop material 'B' is a knitted loop made similar to that described in US Patent 5,605,729, Example 1 available from the 3M Company as XML-01-160. The loop test materials were obtained from a supply roll of the material after unwinding and discarding several revolutions to expose "fresh" material. The loop test material thus obtained was in a relatively compressed state and was used immediately in the peel test before any significant relofting of the loops could occur.

135 Degree Peel Test for Low Profile Loops

A 135 degree peel test was used to measure the amount of force that was required to peel a sample of the mechanical fastener hook material from a sample of low profile loop fastener material. A 1.9 cm x 2.5 cm strip of the mechanical fastener to be tested was cut with the long dimension being in the machine direction of the web. A 2.5 cm wide paper leader was attached to the smooth side of one end of the hook strip. The hook materials were fastened to the low profile loop material using the following procedure: The hook material, with hook side down, was placed onto the low profile loop backsheet material of a diaper. A 4.1 kg weight measuring 7.6 cm x 7.6 cm with medium grit abrasive paper on the bottom surface, was placed on top of the hook material. To engage the hook with the backsheet loop material, the diaper was held securely flat and the weight was twisted 45 degrees to the right, then 90 degrees to the left, then 90 degrees right and then 45 degrees left. The weight was then removed and the diaper was held firm against the surface of a 135 degree jig stand mounted into the lower jaw of an Instron™ Model

1122 tensile tester. The loose end of the paper leader attached to the hook material was placed in the upper jaw of the tensile tester. A crosshead speed of 30.5 cm per minute and a chart recorder set at a chart speed of 50.8 cm per minute was used to record the peel force as the hook strip was peeled from the loop material at a constant angle of 135 degrees. An average of the four highest force peaks was recorded in grams and was reported in grams/2.54 cm-width. 10 different locations were tested on each diaper with the average of the 10 being reported in Table 4.

Three different low profile loop materials were used to measure the performance of the mechanical fastener hook material. Loop material 'C' is the nonwoven side (i.e. outward facing side) of the backsheet of a Loving Touch diaper size 3. Loop material 'D' is the nonwoven side (i.e. outward facing side) of the backsheet of a Walgreens Supreme diaper size 4. Loop material 'E', was cut from a Leggs Sheer Energy B nylon stocking. The fabric was stretched by hand approximately 200% and then attached to a 5 cm x 15 cm steel panel using double-coated adhesive tape. The thickness of the fabric was measured in the stretched condition using an optical microscope. Twelve measurements were averaged to obtain a thickness of 239 microns.

Hook Dimensions

The dimensions of the Example and Comparative Example hook materials were measured using a Leica microscope equipped with a zoom lens at a magnification of approximately 25X. The samples were placed on a x-y moveable stage and measured via stage movement to the nearest micron. A minimum of 3 replicates were used and averaged for each dimension. In reference to the Example and Comparative Example hooks, as depicted generally in Figs. 5, 6, 7, 11, 12, 13 and 14 hook width is indicated by distance 23, hook height is indicated by distance 20, arm droop is indicated by distance 24, and hook thickness is indicated by distance 21.

Molecular Orientation and Crystallinity

The orientation and crystallinity of the Example and comparative example hook materials were measured using X-ray diffraction techniques. Data was collected using a Bruker microdiffractometer (Bruker AXS, Madison, Wisconsin), using copper K_{α} radiation, and HiSTAR™ 2-dimensional detector registry of scattered radiation. The

diffractometer was fitted with a graphite incident beam monochromator and a 200 micrometer pinhole collimator. The X-ray source consisted of a Rigaku RU200 (Rigaku USA, Danvers, MA) rotating anode and copper target operated at 50 kilovolts (kV) and 100 milliamperes (mA). Data was collected in transmission geometry with the detector centered at 0 degrees (2θ) and a sample to detector distance of 6 cm. Test specimens were obtained by cutting thin sections of the hook materials in the machine direction after removing the hook arms. The incident beam was normal to the plane of the cut sections and thus was parallel to the cross direction of the extruded web. Three different positions were measured using a laser pointer and digital video camera alignment system. Measurements were taken near the center of the head portion 17, near the midpoint of the stem portion 15, and as close as possible to the bottom of the stem portion 17 just slightly above the surface 12 of the backing 11. The data was accumulated for 3600 seconds and corrected for detector sensitivity and spatial linearity using GADDS™ software (Bruker AXS Madison, Wisconsin). The crystallinity indices were calculated as the ratio of crystalline peak area to total peak area (crystalline + amorphous) within a 6 to 32 degree (2θ) scattering angle range. A value of one represents 100 percent crystallinity and value of zero corresponds to completely amorphous material (0 percent crystallinity). The percent molecular orientation was calculated from the radial traces of the two-dimensional diffraction data. Background and amorphous intensities were assumed to be linear between the 2θ positions defined by traces (A) and (C) defined below. The background and amorphous intensities in trace (B) were interpolated for each element and subtracted from the trace to produce (B'). Plot of trace (B') has constant intensity in absence of orientation or oscillatory intensity pattern when preferred orientation present. The magnitude of the crystalline fraction possessing no preferred orientation is defined by the minimum in the oscillatory pattern. The magnitude of the oriented crystalline fraction is defined by the intensity exceeding the oscillatory pattern minimum. The percent orientation was calculated by integration of the individual components from trace (B').

Trace (A): leading background edge and amorphous intensity; 12.4 - 12.8 degrees (2θ) radially along χ, 0.5 degree step size.

Trace (B): random and oriented crystalline fractions, background scattering, and amorphous intensity; 13.8 - 14.8 degrees (2θ) radially along χ , 0.5 degree step size.

Trace (C): trailing background edge and amorphous intensity; 15.4 to 15.8 degrees (2θ) radially along χ, 0.5 degree step size.

Trace (B'): random and oriented crystalline fractions obtained by subtraction of amorphous and background intensity from trace (B).

scattering angle center of trace (A): (12.4 to 12.8) deg. = 12.6 deg. 2θ

center of trace (B): (13.8 to 14.8) deg. = 14.3 deg. 2θ

center of trace (C): (15.4 to 15.8) deg. = 15.6 deg. 2θ

Interpolation constant = (14.3 - 12.6) / (15.6 - 12.6) = 0.57

for each array element [i]:

$$\text{Intensity}_{(\text{amorphous + background})}[i] = [(C[i] - A[i]) * 0.57] + A[i]$$

$$B'[i] = B[i] - \text{Intensity}_{(\text{amorphous + background})}[i]$$

From a plot of B' [i] versus [i] :

$B'_{(\text{random})}[i]$ = intensity value of minimum in oscillatory pattern

$$B'_{(\text{oriented})}[i] = B'[i] - B'_{(\text{random})}[i]$$

Using a Simpson's Integration technique and the following areas the percent of oriented material was calculated.

$B'[i]$ = total crystalline area (random + oriented) = $\text{Area}_{(\text{total})}$

$B'_{(\text{oriented})}[i]$ = oriented crystalline area = $\text{Area}_{(\text{oriented})}$

$B'_{(\text{random})}[i]$ = random crystalline area = $\text{Area}_{(\text{random})}$

$$\%\ \text{oriented material} = (\text{Area}_{(\text{oriented})} / \text{Area}_{(\text{total})}) \times 100$$

Comparative Example C1

A mechanical fastener hook material web was made using the apparatus shown in Figure 1. A polypropylene/polyethylene impact copolymer (SRC7-644, 1.5 MFI, Dow Chemical) was extruded with a 6.35 cm single screw extruder (24:1 L/D) using a barrel temperature profile of 177°C-232°C-246°C and a die temperature of approximately 235°C. The extrudate was extruded vertically downward through a die having an opening cut by electron discharge machining. After being shaped by the die, the extrudate is quenched in a water tank at a speed of 6.1 meter/min with the water being maintained at approximately 10°C. The web was then advanced through a cutting station where the ribs

(but not the base layer) were transversely cut at an angle of 23 degrees measured from the transverse direction of the web. The spacing of the cuts was 305 microns. After cutting the ribs, the base of the web was longitudinally stretched at a stretch ratio of approximately 4.1 to 1 between a first pair of nip rolls and a second pair of nip rolls to further separate the individual hook elements to approximately 8 hooks/cm. There were approximately 10 rows of ribs or cut hooks per centimeter. The upper roll of the first pair of nip rolls was heated to 143°C to soften the web prior to stretching. The general profile of this hook is depicted in Fig. 5.

Example 1

The web of comparative example C1 was subjected to a non-contact heat treatment on the hook side of the web by passing said web underneath a 36 cm wide ribbon flame burner Aerogen (Alton Hampshire, UK) at a speed of 90 meter/minute with a burner to film gap of 8 mm. The flame power was 74kJ/hour. The smooth base film side of the web was supported on a chill roll maintained at approximately 18°C. The general profiles of the resulting heat treated hook are depicted in Figs. 6a and 6b. The performance of the hook material web against nonwoven loop material 'A' was measured using a 135° peel test with the results shown in Table 1 below. The peel force of the heat-treated web was approximately 63% greater than the non-heated Comparative Example 1.

Example 2

The web of Comparative Example C1 was subjected to a non-contact heat treatment on the hook side of the web by passing said web underneath a bank of 6-1000 watt 1 micron wavelength infrared bulbs at a speed of 2.1 meter/min. The hook to bulb spacing was approximately 2.5 cm. The smooth base film side of the web was supported on a chill roll maintained at approximately 66°C. The general profiles of the resulting heat treated hook are depicted in Figs. 7a and 7b. The performance of the hook material web against nonwoven loop material 'A' was measured using a peel test with the results shown in Table 1 below. The 135° peel force of the heat-treated web was approximately 206% greater than the non-heat treated Comparative Example C1.

Comparative Example C2

A mechanical fastener hook material web was made as in Comparative Example 1 except the web was extruded at a speed of 9.1 meter/min to increase the amount of melt flow induced molecular orientation in the extrudate. The general profile of this hook is depicted in Fig. 5.

Example 3

The web of Comparative Example C2 was subjected to a non-contact heat treatment on the hook side of the web by passing said web underneath a bank of 6-2000 watt 1 micron wavelength infrared bulbs at a speed of 3.0 meter/min. The hook to bulb spacing was approximately 1.6 cm. The smooth base film side of the web was supported on a chill roll maintained at approximately 66°C. The performance of the hook material web against nonwoven loop material 'A' was measured using a peel test with the results shown in Table 1 below. The 135° peel force of the heat-treated web was approximately 37% greater than the non-heat treated Comparative Example C2.

Comparative Example C3

A mechanical fastener hook material web was made as in Comparative Example 1 except the extrudate was pulled from the die lip at a 20 degree angle from vertical so as to produce a cross-sectional profile as shown in Fig. 11. Hook spacing was 16 rows of hooks per centimeter.

Example 4

The web of Comparative Example C3 was subjected to a non-contact heat treatment on the hook side of the web by passing said web underneath a bank of 3-4500 watt 3 micron wavelength infrared bulbs at a speed of 10.0 meter/min producing hook members such as shown in Fig. 11 with a hook head portion 77 and stem portion 75 and a base 73. . The hook to bulb spacing was approximately 2.5 cm. The smooth base film side of the web was supported on a chill roll maintained at approximately 66°C. The performance of the hook material web against nonwoven loop material 'A' was measured using a 135° peel test with the results shown in Table 1 below. The peel force of the heat-

treated web was approximately 254% greater than the non-heat treated Comparative Example C3.

Example 5

The web of Comparative Example C3 was subjected to a non-contact heat treatment on the hook side of the web by passing said web underneath a perforated metal plate at a speed of 25.0 meter/min producing hook members having a profile substantially as shown in Fig. 11. Hot air at a temperature of approximately 185°C, provided by a 15 kW electric heater, was blown through the perforations in the metal plate onto the hook side of the web at a velocity of approximately 3350 meter/min. The hooks were approximately 46 cm from the perforated plate. The smooth base film side of the web was supported on a chill roll at approximately 149°C. After heat treatment the web was cooled by passing the web over a chill roll maintained at 11°C. The performance of the hook material web against nonwoven loop material 'A' was measured using a 135° peel test with the results shown in Table 1 below. The peel force of the heat-treated web was approximately 136% greater than the non-heat treated Comparative Example C3.

Comparative Example C4

A mechanical fastener hook material web was made as in comparative example 1 except the opening in the die was shaped as shown in Fig. 14 (after heat treating) and the spacing of the cuts was 267 microns prior to stretching the web.

Example 6

The web of comparative example C4 was subjected to a non-contact heat treatment on the hook side of the web by passing said web underneath a bank of 3-4500 watt 3 micron wavelength infrared bulbs at a speed of 10.0 meter/min producing hook members 90 such as shown in Fig. 14. The hook to bulb spacing was approximately 2.5 cm. The smooth base film side of the web was supported on a chill roll maintained at approximately 66°C. The performance of the hook material web against nonwoven loop material 'A' and knitted loop material 'B' was measured using a 135° peel test with the results shown in Table 1 below. The peel force of the heat-treated web using loop material

'A' was approximately 112% greater than the non-heat treated Comparative Example C4 and 32% greater when using loop material 'B'.

Comparative Example C5

A mechanical fastener hook material web was made as in Comparative Example 1 except a high density polyethylene resin (D450 4.5 MI, 0.942 density, Chevron Philips) blended with 2% MB50 silicone/PP masterbatch (Dow Corning) processing aid was used to form the extrudate at a melt temperature of approximately 238°C. The opening in the die was shaped to produce the profile 80 depicted in Fig. 12. After quenching the extrudate and cutting of the ribs the web was oriented in the machine direction 3.5:1.

Comparative Example C6

A mechanical fastener hook material web, available from the 3M Corporation as KN-3425, was made similar to Comparative Example 1. The dimensions of the hook material are shown in Table 3.

Example 7

The web of Comparative Example C5 was subjected to a non-contact heat treatment on the hook side of the web by passing said web underneath a bank of 6-2000 watt 1 micron wavelength infrared bulbs at a speed of 4.0 meter/min producing hook member 85, substantially as shown in Fig. 13. The hook to bulb spacing was approximately 1.6 cm. The smooth base film side of the web was supported on a chill roll maintained at approximately 66°C. The performance of the hook material web against nonwoven loop material 'A' was measured using a 135° peel test with the results shown in Table 1 below. The peel force of the heat-treated web was approximately 151% greater than the non-heat treated Comparative Example C5.

Example 8

A web was made similar to Comparative Example C3 except the extrudate was pulled from the die lip at a 20 degree angle from vertical so as to produce a slightly different cross-sectional profile. The web was subjected to a non-contact heat treatment on the hook side of the web by passing said web underneath a perforated metal plate at a

speed of 25.0 meter/min producing hook members having a profile substantially as shown in Fig. 11. Hot air at a temperature of approximately 185°C, provided by a 15 kW electric heater, was blown through the perforations in the metal plate onto the hook side of the web at a velocity of approximately 3350 meter/min. The hooks were approximately 46 cm from the perforated plate. The smooth base film side of the web was supported on a chill roll at approximately 149°C. After heat treatment the web was cooled by passing the web over a chill roll maintained at 11°C. The dimensions of the resulting heat-treated hook material are shown in Table 3 below and the peel performance against low profile loops is shown in Table 4. The peel force of the heat-treated web was approximately 62% and 60% greater respectively, for low profile loops 'C' and 'D', than the non-heat treated Comparative Example C6.

<u>Example 9</u>

A web was made similar to Comparative Example C3 except the extrudate was pulled vertically from the die lip. The web was subjected to a non-contact heat treatment on the hook side of the web by passing said web underneath a perforated metal plate at a speed of 25.0 meter/min producing hook members having a profile substantially as shown in Fig. 11. Hot air at a temperature of approximately 185°C, provided by a 15 kW electric heater, was blown through the perforations in the metal plate onto the hook side of the web at a velocity of approximately 3350 meter/min. The hooks were approximately 46 cm from the perforated plate. The smooth base film side of the web was supported on a chill roll at approximately 149°C. After heat treatment, the web was cooled by passing the web over a chill roll maintained at 11°C. The dimensions of the resulting heat-treated hook material are shown in Table 3 below and the peel performance against low profile loops is shown in Table 4. The peel force of the heat-treated web was approximately 140% and 107% greater respectively, for low profile loops 'C' and 'D', than the non-heat treated Comparative Example C6.

<u>Example 10</u>

A web was made similar to Comparative Example C3 except a different die plate was used to produce a tapered stem having a larger width at the base of the stem than at the top of the stem. The web was subjected to a non-contact heat treatment on the hook

side of the web using the following procedure. A 13 cm x 43 cm piece of web was placed onto a 13 cm x 43 cm steel plate(1.3 cm thick), hook-side up, and edge clamped to prevent the web from shrinking. Hot air from a Master brand hot air gun at 400°C was blown vertically down onto the web by passing the air gun uniformly over the web for about 10 seconds. The dimensions of the resulting heat-treated hook material are shown in Table 3 below and the peel performance against low profile loops is shown in Table 4. The peel force of the heat-treated web was approximately 321% and 177% greater respectively, for low profile loops 'C' and 'D', than the non-heat treated Comparative Example C6.

Example 11

A web was made similar to the web of Comparative Example C1 except the base of the web was longitudinally stretched at a stretch ratio of approximately 3.65 to 1 between a first pair of nip rolls and a second pair of nip rolls to further separate the individual hook elements to approximately 8.5 hooks/cm. There were approximately 15 rows of ribs or cut hooks per centimeter. The web was then subjected to a non-contact heat treatment on the hook side of the web by passing said web underneath a perforated metal plate at a speed of 8.9 meter/min producing hook members having a profile similar to those in Example 9 and shown in Fig. 11. Hot air at a temperature of approximately 185°C, provided by a 15 kW electric heater, was blown through the perforations in the metal plate onto the hook side of the web at a velocity of approximately 3350 meter/min. The hooks were approximately 46 cm from the perforated plate. The smooth base film side of the web was supported on a chill roll at approximately 149°C. After heat treatment the web was cooled by passing the web over a chill roll maintained at 11°C.

Example 12

A web was made similar to the web of Example 11 except the web was longitudinally stretched at a stretch ratio of approximately 2.5 to 1 between a first pair of nip rolls and a second pair of nip rolls prior to the cutting step to increase orientation of the web prior to cutting of the ribs. The upper roll of the first pair of nip rolls was heated to 143°C to soften the web prior to stretching. After stretching, the web was cut as in Example 11 and then longitudinally stretched at a stretch ratio of approximately 3.65 to 1 between a first pair of nip rolls and a second pair of nip rolls to further separate the

individual hook elements to approximately 8.5 hooks/cm. The web was then subjected to a non-contact heat treatment on the hook side of the web as described in Example 11.

Table 1

Hook Material	Hook width (μm)	Hook Height (μm)	Arm Droop (μm)	Hook Thickness (μm)	Peel Force Loop 'A' (grams)	Peel Force Loop 'B' (grams)
C1	536	573	217	340	202	---
1	663	582	301	85	329	---
2	682	606	341	179	619	---
C2	479	512	147	309	164	---
3	703	678	229	133	225	---
C3	395	514	128	274	270	---
4	483	641	193	171	955	---
5	481	665	172	180	638	---
C4	611	819	262	257	382	541
6	774	992	399	154	811	716
C5	448	500	143	341	186	---
7	547	526	174	201	466	---

Comparative Example C2 and Example 3 were measured to show the change in molecular orientation and crystallinity due to heat treatment of the webs of the invention. The results are shown in Table 2 below. When heat is applied to the oriented hook elements, the molecular orientation decreases dramatically from the top down to the base, and crystallinity increases due to annealing effects.

Table 2

Hook Material	Crystalline Index (top)	% Molecular Orientation (top)	% Molecular Orientation (body)	% Molecular Orientation (base)
C2	0.30	36.3	52.0	85.6
3	0.39	0.0	0.0	80.4

Table 3 below shows the effect of non-contact heat treatment on hook dimensions. Hook thickness decreases dramatically upon the application of heat to hooks having significant molecular orientation.

Table 3

Hook Material	Hook width (μm)	Hook Height (μm)	Arm Droop (μm)	Hook Thickness (μm)	Hooks/cm CD	Stem Width (base) (μm)	Stem Width (top) (μm)
C6	521	485	246	343	10	232	231
8	487	511	176	101	14	233	242
9	544	426	136	98	14.2	227	279
10	384	645	112	122	18.9	247	153
11	470	555	113	143	14.7	240	228
12	449	487	117	70	23.8	196	217

The thicknesses of the low profile loops 'C' and 'D' were determined from scanning electron microscopic (SEM) photos. The nonwoven diaper backsheets were carefully cut with a razor and SEM photos were taken of the cross-section. The distance from the loop/film interface to the top of the loop pile was measured with a ruler from the photographs and converted to microns. Three locations were measured for three different replicates. The nine readings were averaged and are reported below.

Table 4 below shows that as the ratio of hook arm droop to loop thickness decreases, the peel force to thin, low profile nonwoven loops increases dramatically.

Table 4

	Loop Thickness (μm)			Arm Droop/Loop Thickness Ratio			Peel Force (gms/2.5cm)		
Hook Material	Loop C	Loop D	Loop E	Loop C	Loop D	Loop E	Loop C	Loop D	Loop E
C6	133	154	239	1.85	1.6	1.03	78	110	308
8	133	154	239	1.32	1.14	0.74	126	176	409
9	133	154	239	1.02	0.88	0.57	187	228	533
10	133	154	239	0.84	0.73	0.47	328	305	542

WE CLAIM:

1. A unitary hook fastener of a resiliently flexible, polymeric resin comprising a base film layer having generally parallel upper and lower major surfaces, with at least 50 spaced hook members per square centimeter projecting from the upper surface of said base, said hook members having a height from said upper surface of less than 1000 μm and each comprising a stem portion attached at one end to said base, and a head portion at the end of said stem portion opposite said base, at least the head portions having a thickness of from 50 to 200 μm in a first direction generally parallel to the surfaces of said backing.

2. The unitary hook fastener of claim 1 wherein said stem portion has a width in the range of 50 to 500 μm in a second direction generally at a right angle to said first direction and parallel to the surfaces of said backing; said head portion having a width greater than said stem portion and a total width of from 100 to 800 μm in said second direction and an arm droop of from 100 to 500 μm.

3. A unitary hook fastener according to claim 2 having in the range of 50 to 300 spaced hook members per square centimeter.

4. A unitary hook fastener according to claim 1 having in the range of 70 to 150 spaced hook members per square centimeter.

5. A unitary hook fastener according to claim 1 wherein said polymeric material is a thermoplastic resin and the hook head has rounded corners.

6. A unitary hook fastener according to claim 5 wherein said base has a generally uniform thickness between said upper and lower surfaces of between 30 to 200 μm.

7. A unitary hook fastener according to claim 6 wherein said polymeric material comprises polyethylene, polypropylene, polypropylene-polyethylene copolymers or blends thereof.

8. The unitary hook fastener according to claim 1 wherein at least the hook head portion has a molecular orientation of less than 10 percent.

9. The unitary hook fastener according to claim 8 wherein the hook member base portion adjacent the base has a molecular orientation of at least 10 percent.

10. The unitary hook fastener according to claim 8 wherein the base film layer has a degree of molecular orientation in at least one direction.

11. The unitary hook fastener according to claim 8 wherein the base film layer has a degree of molecular orientation in two directions.

12. The unitary hook fastener according to claim 2 wherein the hook portion thickness is less than a stem portion thickness below the hook portion.

13. The unitary hook fastener according to claim 2 wherein the hook portion thickness is substantially the same as the stem portion thickness below the hook portion.

14. The unitary hook fastener according to claim 12 wherein the hook portion has an arm extending past the stem portion the hook portion arm varies in thickness from a tip of the hook portion arm to a portion of the hook portion arm adjacent the stem.

15. A method of forming a unitary fastener comprising the steps of extruding a thermoplastic resin in a machine direction through a die plate having a continuous base portion cavity and one or more ridge cavities extending from the base portion cavity, the extrusion being sufficient to induce melt flow molecular orientation in the polymer flowing through at least the ridge cavities forming a base portion with ridges, forming projections from the thermoplastic resin extruded through the ridge cavities, and

subsequently heat treating at least a portion of the solidified projections at a temperature and time sufficient to reduce the thickness of the projections.

16. The method of forming unitary fasteners of claim 15 wherein the projections are hook form projections having a stem portion and a head portion.

17. A method for forming unitary hook fastener according to claim 15 wherein the formed hooks are heated at a temperature and time sufficient to shrink at least a portion of the hook head portions of the hook portions by from 5 to 90 percent.

18. A method for forming unitary hook fastener according to claim 13 wherein the hook portions are formed by extruding continuous ridges having a profile of the hook element, on a base portion comprising a film cutting the ridges and subsequently stretching the base layer to separate the individual cut ridges into discrete hook portions.

19. A method for forming unitary hook fastener according to claim 17 wherein at least a portion of the hook head portions are shrunk by at least 30 percent.

20. A method for forming unitary hook fastener according to claim 18 wherein the continuous ridges are stretched in the direction of the ridges prior to cutting of the ridges.

21. A fastener of a resiliently flexible, polymeric resin comprising a base having generally parallel upper and lower major surfaces, with spaced upstanding projections projecting from the upper surface of said base, wherein at least a portion of the projections at an upper portion have a molecular orientation of less than 10 percent and adjacent the base film have a molecular orientation of greater than 10 percent.

22. The fastener of claim 21 wherein a portion of the upstanding projections have a molecular orientation of greater than 10 percent.

23. The fastener of claim 21 wherein a portion of the upstanding projections have a molecular orientation of from 20 to 100 percent.

24. The fastener of claim 19 wherein the projections comprise hook members having a stem portion and a hook head portion where the hook members having a height from said upper surface of less than 5000 μm and each comprising a stem portion attached at one end to said base, and a head portion at the end of said stem portion opposite said base, at least the head portions having a thickness from 50 to 1500 μm, a first direction generally parallel to the surfaces of said backing.

25. A fastener according to claim 24 wherein said stem portion has a width in the range of 50 to 500 μm in a second direction generally at a right angle to said first direction and parallel to the surfaces of said backing; said head portion having a width greater than said stem portion and a total width of from 100 to 5000 μm in said second direction.

26. The fastener according to claim 25 wherein the hook members are provided at a density of at least 10 per square centimeter.

27. A fastener according to claim 24 having in the range of 20 to 300 spaced hook members per square centimeter.

28. A fastener according to claim 24 wherein said polymeric material is a thermoplastic resin.

29. A fastener according to claim 28 wherein said base has a generally uniform thickness between said upper and lower surfaces of between 30 to 200 μm.

30. A fastener according to claim 29 wherein said polymeric material comprises polyethylene, polypropylene, polypropylene-polyethylene copolymers or blends thereof.

31. A fastener according to claim 21 wherein the hook portion thickness is less than a stem portion thickness below the hook portion.

32. A fastener according to claim 21 wherein the hook portion thickness is substantially the same as the stem portion thickness below the hook portion.

33. A fastener according to claim 21 wherein the hook portion has an arm extending past the stem portion the hook portion arm varies in thickness from a tip of the hook portion arm to a portion of the hook portion arm adjacent the stem.

34. A hook and loop fastener system of a unitary hook fastener and a low profile loop laminate, the unitary hook fastener comprising a base having generally parallel upper and lower major surfaces, with at least 50 spaced hook members per square centimeter projecting from the upper surface of said base, said hook members having a height from said upper surface of less than 1000 μm and each comprising a stem portion attached at one end to said base, and a head portion at the end of said stem portion opposite said base, the head portion having a thickness of from 60 to 180 μm and an arm droop of from 50 to 700 μm, the loop laminate comprising a fibrous loop web bonded to a backing layer wherein the loop web has a thickness of from 100 to 300 microns and wherein the ratio of the arm droop to the loop web thickness is 1.5 or less.

35. A hook and loop fastener system of claim 34 wherein the head portion has a thickness of from 50 to 200 μm in a first direction generally parallel to the surface of said backing and the loop web is a nonwoven loop web formed of a nonwoven fibrous web having a thickness of from 100 to 300 microns.

36. The hook and loop fastener system of claim 35 wherein the backing layer is a film layer and the loop web is a nonwoven web point bonded to the film layer.

37. The hook and loop fastener system of claim 36 wherein the backing layer is a coextruded film layer having a bonding layer attached to said nonwoven fibrous web.

38. The hook and loop fastener system of claim 37 wherein the nonwoven web is spunbond nonwoven web.

39. The hook and loop fastener system of claim 35 wherein the ratio of arm droop to nonwoven web thickness is 1.3 or less.

40. The hook and loop fastener system of claim 35 wherein the ratio of arm droop to nonwoven web thickness is 1.0 or less.

41. The hook and loop fastener system of claim 35 wherein said stem portion has a width in the range of 50 to 500 μm in a second direction generally at a right angle to said first direction and parallel to the surfaces of said backing; said head portion having a width greater than said stem portion and a total width of from 100 to 800 μm in said second direction and an arm droop of from 100 to 500 μm.

42. The hook and loop fastener of claim 35 wherein the head portion thickness is from 60 to 80 μm.

43. A hook and loop fastener system of claim 35 wherein the head portion thickness is from 50 to 80 μm having in the range of 50 to 300 spaced hook members per square centimeter.

44. A hook and loop fastener system of claim 35 wherein said polymeric material is a thermoplastic resin and the hook head has rounded corners.

45. A hook and loop fastener system of claim 44 wherein said base has a generally uniform thickness between said upper and lower surfaces of between 30 to 200 μm.

46. A hook and loop fastener system of claim 45 wherein said polymeric material comprises polyethylene, polypropylene, polyethylene-polyethylene copolymers or blends thereof.

47. A hook and loop fastener system of claim 35 wherein at least the hook head portion has a molecular orientation of less than 10 percent.

48. A hook and loop fastener system of claim 47 wherein the hook member base portion adjacent the base has a molecular orientation of at least 10 percent.

49. A hook and loop fastener system of claim 35 wherein the hook portion thickness is less than a stem portion thickness below the hook portion.

50. A hook and loop fastener system of claim 35 wherein the hook portion thickness is substantially the same as the stem portion thickness below the hook portion.

51. A hook and loop fastener system of claim 49 wherein the hook portion has an arm extending past the stem portion the hook portion arm varies in thickness from a tip of the hook portion arm to a portion of the hook portion arm adjacent the stem.

52. A hook and loop fastener system of claim 34 wherein the system has a 135 degree peel force of greater than 120 g/2.5 cm.

53. A hook and loop fastener system of claim 34 wherein the system has a 135 degree peel force of greater than 200 g/2.5 cm.

54. A hook and loop fastener system of claim 34 wherein the hook and loop fastener system is on a garment.

55. A fastener strip of a resiliently flexible, thermoplastic resin comprising a base layer having generally parallel upper and lower major surfaces, with spaced upstanding integral polymeric projections projecting from the upper surface of said base, wherein the base layer has a substantially continuous thickness across its width and wherein at least a first portion of the projections on the upper surface have a thickness or

molecular orientation, less than at least another second portion of the projections on the same upper surface.

56. The fastener strip of claim 55 wherein a portion of the upstanding projections have a molecular orientation of less than 10 percent.

57. The fastener strip of claim 56 wherein a portion of the upstanding projections have a molecular orientation different than another portion of the upstanding projection.

58. The fastener strip of claim 55 wherein the projections comprise hook members having a stem portion and a hook head portion where the hook members having a height from said upper surface of less than 5000 μm and each comprising a stem portion attached at one end to said base, and a head portion at the end of said stem portion opposite said base, at least the head portions having a thickness from 50 to 1500 μm, a first direction generally parallel to the surfaces of said backing.

59. A fastener strip according to claim 58 wherein said stem portion has a width in the range of 50 to 500 μm in a second direction generally at a right angle to said first direction and parallel to the surfaces of said backing; said head portion having a width greater than said stem portion and a total width of from 100 to 5000 μm in said second direction.

60. The fastener strip according to claim 59 wherein the hook members are provided at a density of at least 10 per square centimeter.

61. A fastener strip according to claim 57 wherein a portion of the upstanding projections have a molecular orientation of from 20 to 100 percent.

62. A diaper having a fastener strip of claim 55.

63. The method of form unitary fasteners of claim 15 wherein the extruded thermoplastic film base portion and ridges are length oriented prior to forming the projections.

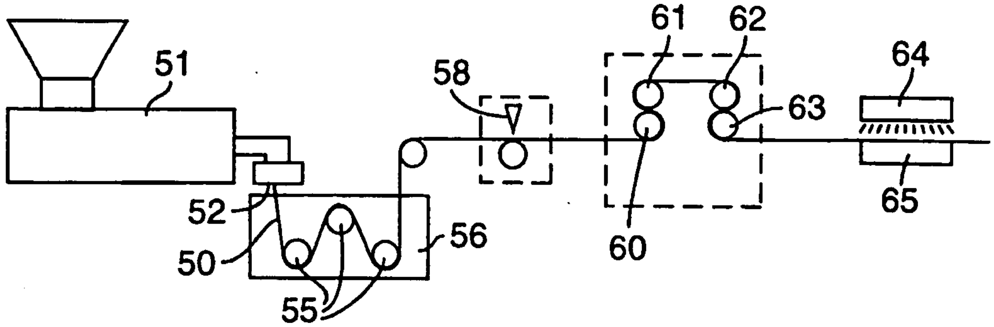

Fig. 1

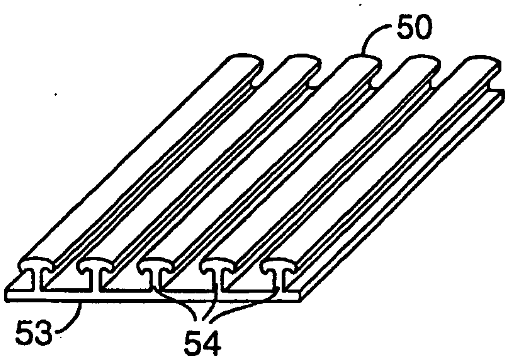

Fig. 2

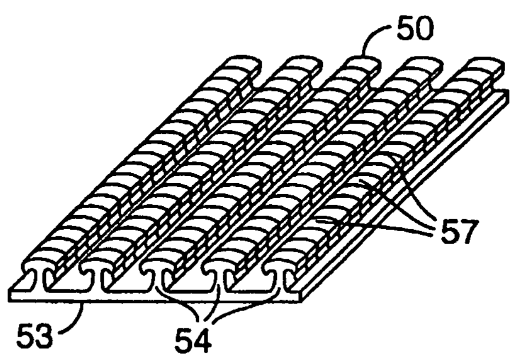

Fig. 3

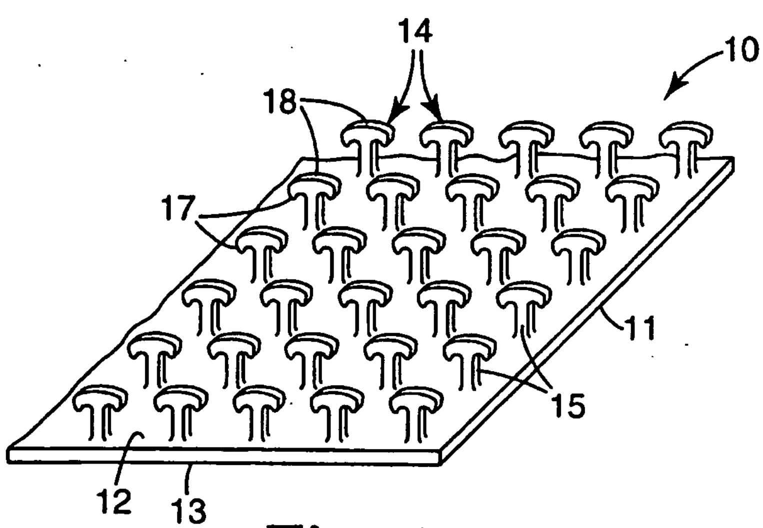

Fig. 4

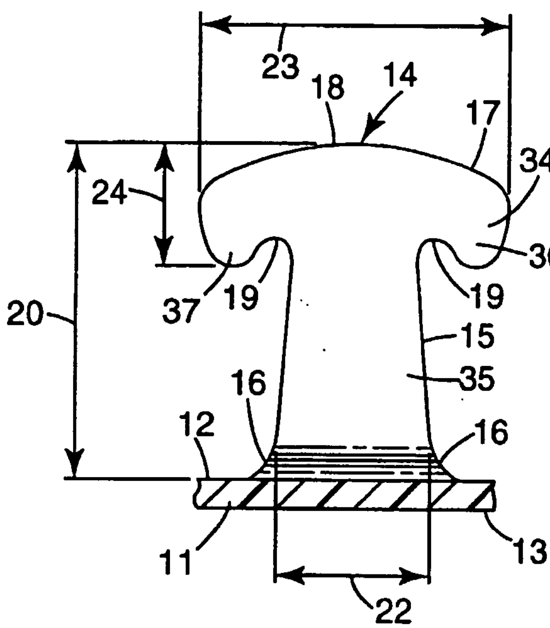

Fig. 5a

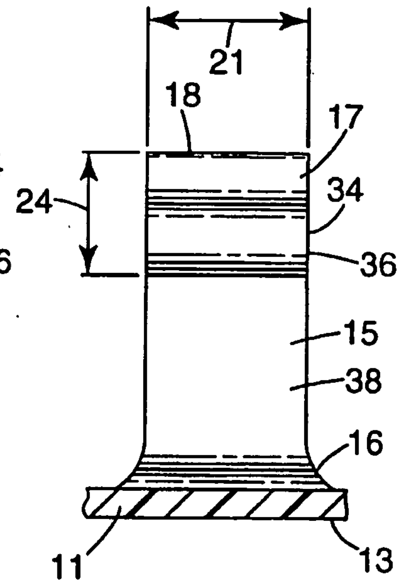

Fig. 5b

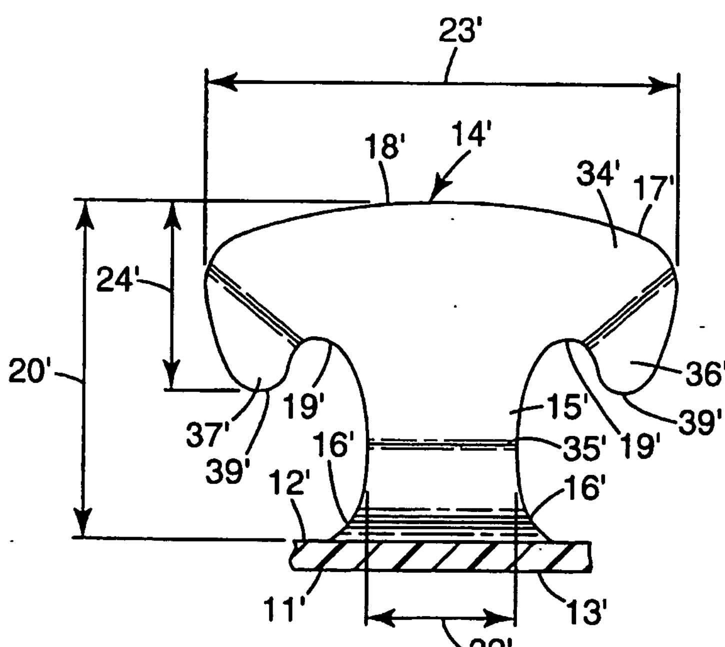

Fig. 6a

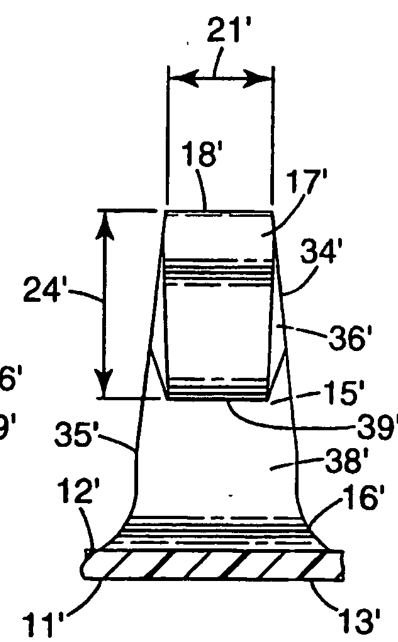

Fig. 6b

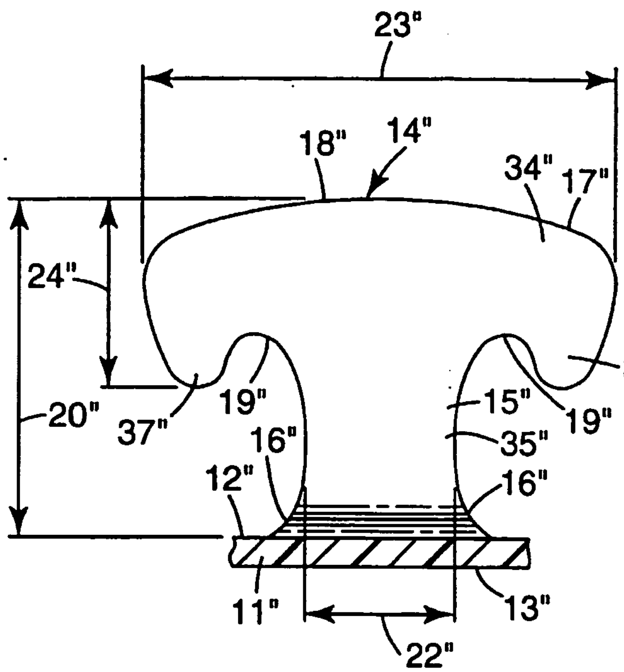

Fig. 7a

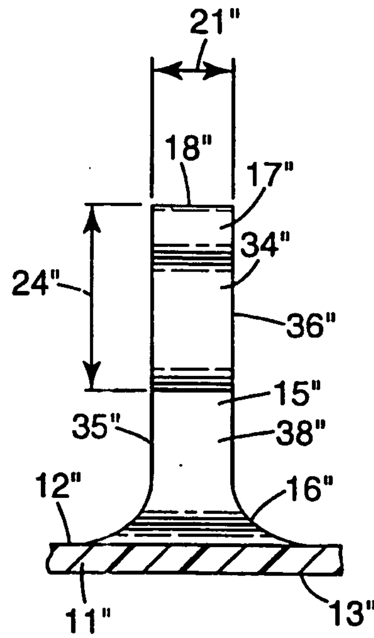

Fig. 7b

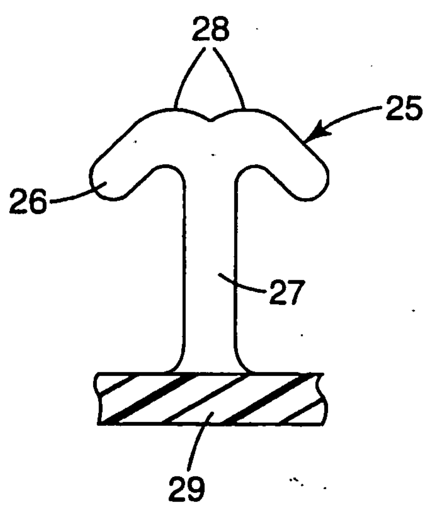

Fig. 8

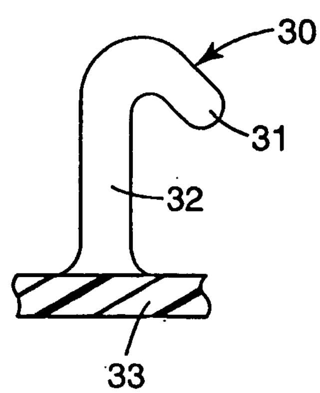

Fig. 9

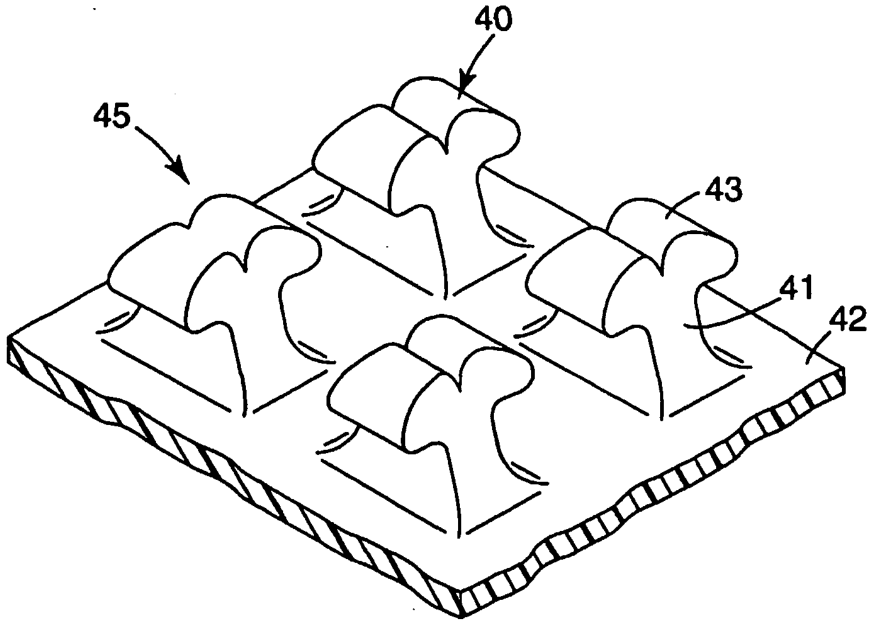

Fig. 10

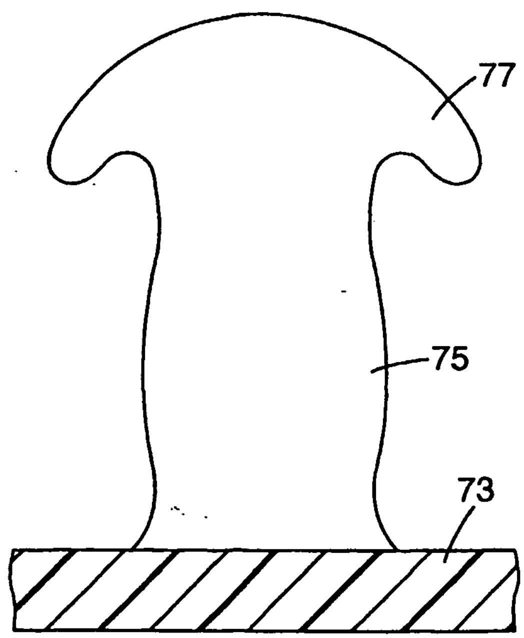

Fig. 11

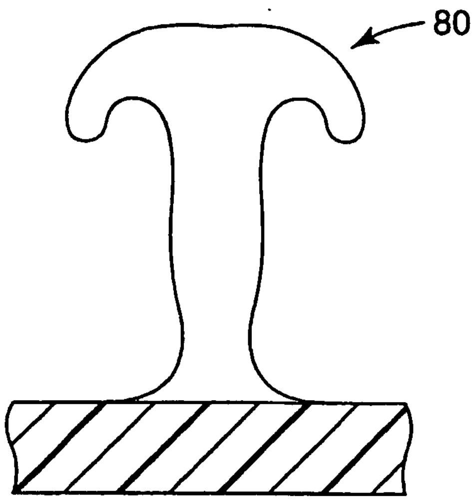

Fig. 12

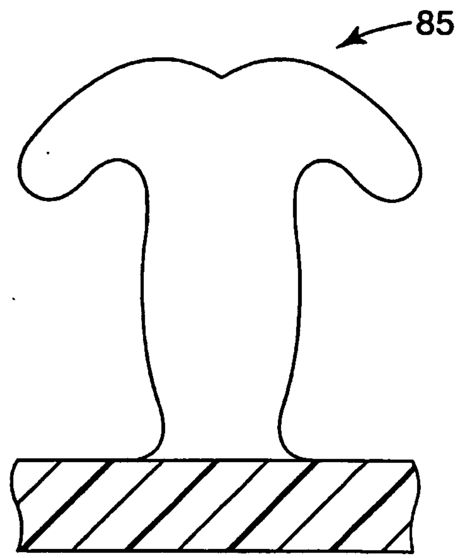

Fig. 13

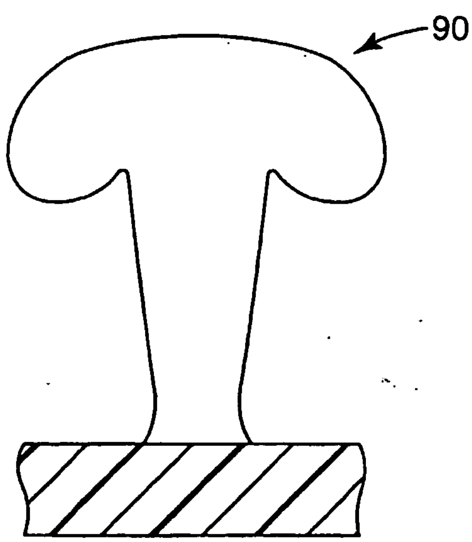

Fig. 14